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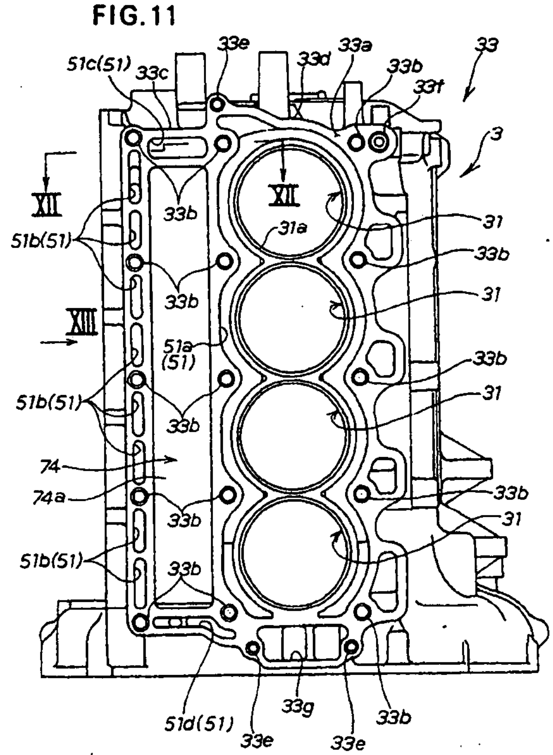
(54) Engine cooling system for outboard motor

(57) An engine (3) includes first exhaust passages (73) formed in a cylinder head (34), a second exhaust passage (74) formed in a cylinder block (33) and communicating with the first exhaust passages (73), and a cooling water passage (50) having water jacket portions formed around combustion chambers (71). The cooling water passage (50) includes a first water jacket (52) and a second water jacket (51). The cylinder head (34) and the cylinder block (33) are fixedly connected together by bolts (59). The second exhaust passage (74) opens at a joining surface (33a) of the cylinder block (33) along cylinders (31), which opening (74a) is surrounded by the bolts (59). The cooling water passage (50) has water jacket portions formed between the bolts (59) in the joining surface (33a) of the cylinder block (33) such that they surround the opening (74a) of the second exhaust passage (74).

FIG. 11



D scription

The present invention relates to an improvement in an engine cooling system for an outboard motor.

Conventionally, an engine cooling system is known from, for example, JP-A- HEI 3-168353 entitled "Exhaust Passage for Internal Combustion Engine".

As shown in Figs. 2 and 4 of the above publication, the disclosed engine cooling system includes a cylinder head, a cylinder block with a plurality of cylinders arranged generally horizontally in vertical juxtaposition, and a water jacket provided to surround the cylinders. An elongate second exhaust passage, opening along the cylinders, is provided at a joining surface of the cylinder block at which to be joined with the cylinder head. The water jacket is arranged at the joining surface of the cylinder block such that it substantially surrounds the opening of the second exhaust passage.

The known system, however, has a drawback in that no part of the water jacket is present at part of an outer wall of the second exhaust passage with the result that the temperature of that part of the wall of the second exhaust passage rises undesirably temporarily.

It is an object of the present invention to provide an engine cooling system capable of cooling an engine uniformly.

According to a first aspect of the present invention, ther is provided an engine cooling system for an outboard motor, which comprises: a cylinder block having a plurality of cylinders disposed generally horizontally in vertical juxtaposition; a cylinder head being capable of coupling with the cylinder block; a plurality of combustion chambers defined within the cylinder block and the cylinder head; first exhaust passages formed in the cylinder head for guiding an exhaust gas from the combustion chambers; a second exhaust passage formed in the cylinder block in such a manner as to communicate with the first exhaust passages; a first water jacket having jacket portions formed around the combustion chambers of the cylinder head; a second water jacket having jacket portions formed around the combustion chambers of the cylinder block; a cooling water passage comprising the first water jacket and the second water jacket, the cylinder block and the cylinder head having joining surfaces to be connected together by plural bolts; the second exhaust passage having an opening which opens at the joining surface of the cylinder block along the cylinders and is surrounded by the bolts; and the cooling water passage having water jacket portions formed between the bolts in the joining surface of the cylinder block such that they surround the opening of the second exhaust passage.

By virtue of the cooling water passage with the water jacket portions formed between the bolts in the joining surface of the cylinder block such that they surround the second exhaust passage opening, it becomes possible to cool the vicinity of the opening of the exhaust passage substantially uniformly.

According to a second aspect of the present invention, there is provided an engine cooling system for an outboard motor, which comprises: a cylinder block having a plurality of cylinders disposed generally horizontally in vertical juxtaposition; a cylinder head for coupling with the cylinder block to define a plurality of combustion chambers; first exhaust passages formed in the cylinder head for guiding an exhaust gas from the combustion chambers; a second exhaust passage formed in the cylinder block and communicating with the first exhaust passages; a second water jacket having jacket portions for cooling the vicinity of the second exhaust passage; a first water jacket having jacket portions for cooling the vicinity of the first exhaust passages; and a relief valve actuated to open and close the second water jacket and the first water jacket by detecting the pressure of cooling water inside the water jackets, wherein that portion of the second water jacket which surrounds an upper side of the second exhaust passage, and that portion of the first water jacket which surrounds an upper side of the first exhaust passage communicate with a drainage passage provided downstream of the relief valve.

In the arrangement according to the second aspect of the invention, when the relief valve is opened to allow the cooling water to flow through the drainage passage downstream thereof, the cooling water flows into the jacket portions surrounding the upper side of the exhaust passages. The jacket portions are cooled by the cooling water flowing thereinto with the result that a sufficient cooling effect can be attained throughout the entire area of the joining surfaces around the block and first exhaust passages. Consequently, it becomes possible to produce a uniform temperature distribution at the wall defining the exhaust passage and to maintain at a uniform temperature portions along the joining surfaces of the cylinder block and the cylinder head.

Even when, for example, the cooling water has a low temperature with the engine operated at a low speed for a long time and the temperature of an exhaust gas abruptly rises by high speed running of the engine, the relief valve may be opened so that the jacket portions surrounding the upper side of the exhaust passage can be cooled by the cooling water flown from the valve, thereby increasing the cooling effect over the entire area of the joining surfaces around the exhaust passage.

In a preferred form, the first water jacket further serves to cool the vicinity of the combustion chambers of the cylinder head and has at least one thermostat mounted thereto and being capable of opening and closing actions by detecting a temperature of the cooling water within the first water jacket. In addition, a drainage passage is provided downstream of the thermostat such that it communicates with the drainage passage positioned downstream of the relief valve. Thus, the temperature of the cooling wat r in the first wat r jacket is controlled preferentially by the thermostat. As a result, it b - comes possible to further improve the cooling effect with respect to the cylinder head by, for example, normally

feeding a large, predetermined quantity of cooling water to the first water jacket.

Desirably, the jacket portion of the second water jacket, which surrounds the upper side of the second exhaust passage, has an upper wall positioned lower than an upper wall defining an uppermost one of the cylinders. This makes it unnecessary for the cylinder block to have a large height so as to provide the jacket portions. The engine can thus be kept small notwithstanding the jacket portion provided thereto for surrounding the upper side of the second exhaust passage.

A preferred embodiment of the present invention will be described in detail hereinbelow, by way of example only, with reference to the accompanying drawings, in which:

Fig. 1 is a side elevational view of an outboard motor according to the present invention;
Fig. 2 is a side elevational view illustrating, partly in section, a vertical multicylinder engine of the outboard motor of Fig. 1;
Fig. 3 is a diagrammatical view showing a cooling water passage of the engine of Fig. 2;
Fig. 4 is a schematic view illustrating the general arrangement of the vertical multicylinder engine;
Fig. 5 is an enlarged cross-sectional view taken along line V-V of Fig. 4;
Fig. 6 is an enlarged cross-sectional view taken along line VI-VI of Fig. 4;
Fig. 7 is an enlarged cross-sectional view taken along line VII-VII of Fig. 4;
Fig. 8 is a cross-sectional view showing an essential part of the engine;
Fig. 9 is an enlarged plan view as seen from line IX-IX of Fig. 4;
Fig. 10 is a cross-sectional view of first and second thermostats shown in Fig. 9;
Fig. 11 is a side elevational view of a cylinder block of the engine;
Fig. 12 is a cross-sectional view taken along line XII-XII of Fig. 11;
Fig. 13 is a view as seen in the direction of arrow XIII of Fig. 11;
Fig. 14 is a cross-sectional view taken along line XIV-XIV of Fig. 13; and
Fig. 15 is a side elevational view of the cylinder head of the engine.

The following description is merely exemplary in nature and is in no way intended to limit the invention or its application or uses.

As shown in Fig. 1, an outboard engine or motor 1 comprises an outboard motor body la and an outboard motor attachment mechanism 15 for attaching the outboard motor body la to the stem of a hull S.

Th outboard motor body la is equipped with a vertical multicylinder engine 3 mounted on an engine mount case (engine support case) 2. An extension case 4 is disposed below the engine mount case 2 to define therein an exhaust expansion chamber. A vertical drive shaft 5 extends vertically through an internal space of the extension case 4 for transmitting the power of the engine 3 to a propeller 8.

A gearcase 6 is connected to a lower end of the extension case 4 and houses therein a bevel gear set 7 for switching or changing over the forward and backward movements of the hull S. The bevel gear set 7 has an output shaft to which the propeller 8 is firmly connected so that the propeller 8 is rotatably driven by the engine power transmitted via the vertical drive shaft 5. The gearcase 6 also houses a cooling water screen 11 which is connected by a cooling water supply pipe 12 to a water pump 13 disposed in the internal space of the extension case 4.

The outboard motor attachment mechanism 15 is a fixture assembly used for securing the outboard motor body la to the stern of the hull S. The attachment mechanism 15 supports the motor body la such that the motor body la can swing in the lateral direction about a vertical swivel shaft 16. The mechanism 15 can also tilt up and down about a horizontal tilt shaft 17.

The engine 3 is covered jointly by an undercase 21 and an engine cover 22. The undercase 21 and the engine cover 22 are detachably connected together by a lock mechanism 25. The undercase 21 has a lower end held in contact with an upper end of an undercover 23 which is provided to cover the mount case 2. The undercover 23 has the function of a decorative or ornamental cover. An oil pan 24 is connected to a lower end of the mount case 2.

As shown in Fig. 2, the vertical multicylinder engine 3 is a multicylinder four-stroke water-cooled engine with four cylinders 31 disposed horizontally in vertical juxtaposition and a crankshaft 32 disposed vertically. With the engine thus arranged, a cylinder block 33 and a cylinder head 34 have respective joining surfaces lying substantially vertically, and the cylinder head 34 and a head cover 35 have respective joining surfaces (mating surfaces) lying in a substantially vertical plane.

The engine 3 is disposed horizontally with its cylinder head 34 and head cover 35 located at the rear side (left-hand side of Fig. 1) of the outboard motor 1.

In Fig. 2, designated by reference numeral 36 is a crankcase bolted to the cylinder block 33 while reference numeral 37 denotes a piston slidable in each cylinder 31.

The crank shaft 32 has an upper end to which a first pulley 32a and a second pulley 32b are connected one behind the other. The crankshaft 32 drives a camshaft 38 via a first endless belt 39 trained around the first pulley 32a and a crankshaft pulley (not designated). The crankshaft 32 also drives an alternator 41 via a second endless belt 42 trained around the second pulley 32b and an alternator pulley (not designated). The first and second endless belts 39, 42 are covered by a belt cover 44. The belt cover 44 has formed therein a ventilating

hole or opening 44a through which air inside the belt cover 44 is driv n out to the outside of the engine cover 22. Th engine cover 22 has an air intake hole 22a formed at an upper portion thereof. The crankshaft 32 has a lower end to which a flywheel 43 with toothed ring 43a is attached for engagement with a pinion gear (not shown) on a starter motor 64 (Fig. 4).

An oil filler hole 45 is provided in an inclined condition at a front surface of the crankcase 36. Reference numeral 46 denotes an oil filter; 47, an intake silencer (induction box) defining therein a silencer chamber; and 48, a throttle valve device.

The undercase 21 is bolted to the mount case 2 with a rubber vibration isolator 27 disposed therebetween.

Fig. 3 diagrammatically shows a cooling water passage in the vertical multicylinder engine 3, which is formed by water jackets.

The engine 3 has a cooling water passage 50 connected to the cooling water supply pipe 12. The cooling water passage 50 is composed of a plurality of first cooling passages 51A formed by a water jacket 51 in the cylinder block 33 (hereinafter referred to as "second water jacket"), a second cooling passage 52A formed by a water jacket 52 in the cylinder head 34 (hereinafter referred to as "first water jacket"), a bypass passage 53, and a drainage passage 54. The drainage passage 54 is provided to draw off the cooling water to the outside of the engine 3 after the cooling water flew past the first and second cooling passages 51A, 52A.

The first cooling passages 51A communicate with the drainage passage 54 via a first thermostat 81 and a drainage passage 54A provided downstream of the first thermostat 81. The second cooling passage 52A communicates with the drainage passage 54 via a second thermostat 88 and a drainage portion 54B provided downstream of the second thermostat 88. The bypass passage 53 communicates with the drainage passage 54 via a relief valve 90.

The first thermostat 81 is a temperature-controlled valve which operates to open and close the first cooling passages 51A depending on the cooling water temperature inside the first cooling passages 51A. The second thermostat 88 is a temperature-controlled valve which operates to open and close the second cooling passage 52A depending on the cooling water temperature inside the second cooling passage 52A.

The relief valve 90 is a pressure-operated valve which operates to open and close the bypass passage 53 depending on the cooling water pressure inside the bypass passage 53, that is, the first and second cooling passages 51A, 52A.

In Fig. 3, reference numeral 55 designates a plurality of walls provided in the cylinder block 33 to define the cooling water passage 50; and 56, a gasket disposed between respective contact or joining surfaces of the cylind r block 33 and the cylinder head 34 to provide a hermetic seal between the cylinder block and the cylinder head 34.

Fig. 4 is a side elevational view of the vertical multicylinder engine 3 of Fig. 2 as seen from an opposite or rear side.

As shown in Fig. 4, th first thermostat 81, which is incorporated in the cooling water passage 50 of the engine 3 together with the second thermostat 88 and the relief valve 90, is disposed on an upper surface of the cylinder block 33. The relief valve 90 is disposed adjacent to the first thermostat 81 and located on an upper part of one side surface of the cylinder block 33. The second thermostat 88 is disposed on an upper surface of the cylinder head 34.

Since the first and second thermostats 81, 88 are disposed on the upper surface of the cylinder block 33 and the upper surface of the cylinder head 34, respectively, the relief valve 90 can be mounted on the upper part of the side surface of the cylinder block 33.

More particularly, a part of the first cooling passage 51A, the bypass passage 53 and the drainage passage 54 are disposed on the same side (front side of the sheet of Fig. 4) of the cylinder block 33. This part of the first cooling passage 51A, the bypass passage 53 and the drainage 54 extend vertically and are covered by a housing 57 and a cover 58, as detailed later with reference to Fig. 5.

In order to enable the cooling water passage 50 to be cleaned or washed with washing water, the engine 3 further includes a washing water inlet 61, a hose 62, and a check valve 63. The check valve 63 is mounted on the cylinder head 34. In Fig. 4, reference numeral 64 denotes the starter motor described above; 65, an electric equipment box; and 66, ignition plugs.

Fig. 5 is an enlarged cross-sectional view taken along line V-V of Fig. 4. As shown in this figure, the cylinder block 33 has two vertically elongated recessed portions 33i, 33j formed in lateral juxtaposition in the side surface of the cylinder block 33. Respective front sides (open sides) of the recessed portions 33i, 33j are closed by the housing 57. The above-mentioned part of the first cooling passage 51A is defined jointly by the recessed portion 33i and the housing 57. The drainage passage 54 is defined jointly by the recessed portion 33j and the housing 57. The housing 57 has a vertically elongated recessed portion 57a formed in a left side portion of the front surface of the housing 57. The front side (open side) of the recessed portion 57a is closed by the cover 58. The cover 58 and the recessed portion 57a jointly define the bypass passage 53.

As described later, the cylinder block 33 is coupled to the cylinder head 34 by screwing a plurality of bolts 59, 59 into screw openings 33b, 33b through bolt inserting openings 34b, 34b.

Fig. 6 is an enlarged cross-sectional view taken along line VI-VI of Fig. 4, showing the second water jacket 51 (th first cooling passage 51A) which communicates with the first water jacket 52 (the second cooling passage 52A). As shown in this figure, the housing 57 is secured by two sets of bolts B1 and B2 to the cylinder

block 33 to thereby define, jointly with the cylinder block 33, the first cooling passage 51A and the drainage passage 54. The cover 58 is secured to the housing 57 by the bolts B1 and a set of bolts B3 to thereby define, jointly with the housing 57, the bypass passage 53.

Fig. 7 is an enlarged cross-sectional view taken along line VII-VII of Fig. 4. As shown in this figure, the relief valve 90 is comprised of a valve chamber 91, a valve seat 92, a valve member 93 and a valve spring 94. The valve chamber 91 is formed at a position or junction where the bypass passage 53 and the drainage passage 54 communicate with each other. The valve seat 92 is attached to the housing 57 at that portion of the bypass passage 53 which forms a part of the valve chamber 91. The valve seat 92 is made of rubber or synthetic resin so as to produce desired water-tightness between itself and the valve member 93 when the valve member 93 is seated against the valve seat 92. The valve member 93 has a cruciform section and is disposed in the valve chamber 91 such that a disk-like portion of the valve member 93 is movable into and away from sealing engagement with the valve seat 92. The valve spring 94 comprises a compression spring and acts between the cylinder block 33 and the valve member 93 to normally urge the valve member 93 in a direction to close the valve chamber 91. The relief valve 90 operates such that when the pressure of the cooling water coming from the bypass passage 53 exceeds a predetermined pressure, the valve member 93 separates from the valve seat 92 against the force of the valve spring 94 to thereby place the bypass passage 53 and the drainage passage 54 in fluid communication with each other.

Fig. 8 is a cross-sectional view taken along an axis of a second cylinder 31 (the one next to the uppermost cylinder in Fig. 2), showing an essential part of the engine according to the present invention.

The cylinder block 33 is coupled, by the bolts 59 shown in Fig. 5, to the cylinder head 34 with their joining surfaces 33a, 34a mated together via the gasket 56. The cylinder block 33 and the cylinder head 34 have a plurality of combustion chambers 71 arranged in vertical juxtaposition.

The cylinder head 34 includes head intake passages 72 for guiding an intake air to the respective combustion chambers 71, first or head exhaust passages 73 for guiding an exhaust air from the respective combustion chambers 71, and the first water jacket 52 having jacket portions disposed around the combustion chambers 71 for cooling the vicinity of the combustion chambers 71 and the vicinity of the first exhaust passages 73.

The cylinder block 33 includes a second or block exhaust passage 74 which communicates with the first exhaust passages 73, and the second water jack t 51 having jacket portions disposed around the combustion chambers 71 for cooling the vicinity of the combustion chambers 71 and the vicinity of the second exhaust passage 74. The first exhaust passages 73 and the second xhaust passage 74 jointly form an exhaust passage 75. The exhaust air flows from the exhaust passage 75 to the outside of the outboard motor 1 via an exhaust tube 26 shown in Fig. 1. Reference numeral 76 denotes an inlet valve. Designated by reference numeral 77 is an exhaust valve.

Fig. 9 is an enlarged plan view taken along line IX-IX of Fig. 4, showing the first thermostat 81 mounted on an upper surface of the cylinder block 33 and the second thermostat 88 mounted on an upper surface of the cylinder head 34.

As shown in Fig. 9, the first and second thermostats 81, 88 are disposed adjacent to each other, with their drainage portions 54A, 54B disposed in confronting relation to each other, so that the two thermostats can use the same drainage passage 54 in common via the drainage portions 54A, 54B. The first and second thermostats 81, 88 mounted on the respective upper surfaces of the cylinder block 33 and the cylinder head 34 are arranged so as not to interfere with the first endless belt 39 and the belt cover 44.

Fig. 10 is a cross-sectional view illustrating the first and second thermostats 81, 88 with the drainage portions 54A, 54B provided downstream thereof and communicating with the drainage passage 54 disposed downstream of the relief valve 90.

The first thermostat 81 is of the so-called "wax" type which operates using the temperature-dependent volumetric difference (by expansion and contraction) of a paraffin. The thermostat 81 is comprised of a valve chamber 82, a valve seat 83, a valve member 84, a valve spring 85 and a wax holding portion or container 86. The valve chamber 82 is defined in the cylinder block 33 and communicates with the second water jacket 51. The valve seat 83 is made of a rubber or synthetic resin material to provide a hermetic seal thereat and disposed the upper surface of the cylinder block 33. The valve member 84 is provided in such a manner as to close an opening in the valve seat 83 and connected to the wax container 86 via a rod 84a. The valve spring 85 is a compression spring normally urging the valve member 84 in a direction to close the opening in the valve seat 83. A cover 87 extends generally from the valve chamber 82 to the drainage portion 54A. In the first thermostat 81, when the temperature of the cooling water in the second water jacket 51 rises over a preset value, the wax in the wax container 86 expands to cause the rod 84a to move to thereby open the valve member 84 against the resilient force of the compression spring 85, so that the second water jacket 51 and the drainage passage 54A communicate with each other.

The second thermostat 88 has the same construction as the first thermostat 81.

The drainage portion 54A provided downstream of the first thermostat 81 also serves as a third jacket portion 51c formed in the joining surface 33a of the cylinder block 33. The drainage portion 54B provided downstream of the second thermostat 88 also serves as a

third jacket portion 52c form d in the joining surface 34a of the cylinder head 34. Thus, the third jacket portions 51c, 52c communicate with the drainage passage 54 provided downstream of the relief valve 90.

Fig. 11 is a side elevational view illustrating the cylinder block 33, as viewed from the side of the joining surface 33a thereof, with the cylinders 31 (four shown in this figure) disposed horizontally in vertical juxtaposition.

The second exhaust passage 74 has a vertically elongate opening 74a formed in the joining surface 33a such that it opens in the direction of juxtaposition of the cylinders 31. In the joining surface 33a around the opening 74a, the screw openings 33b are formed for receiving the bolts 59 shown in Fig. 5. Stated otherwise, the cylinder block 33 has the screw openings 33b formed in the joining surface 33a such that they surround the openings of the cylinders 31 and the opening 74a of the second exhaust passage 74. As shown in Fig. 5, the joining surface 33a of the cylinder block 33 is joined or mated with the joining surface 34a of the cylinder head 34 via the screw openings 33b and the bolts 59.

The cylinder block 33 has a plurality of screw openings (taps) 33e formed at top and bottom outermost (overhung) positions of the cylinder block 33. The cylinder block 33 and the cylinder head 34 are also connected together via the screw openings 33e and bolts thread dly received therein.

The second water jacket 51 has the jacket portions disposed between the screw openings 33b in such a manner as to surround the opening 74a of the second exhaust passage 74.

More specifically, the second water jacket 51 is composed of a first jacket portion 51a surrounding the cylinders 31, a plurality of second jacket portions 51b surrounding a left side of the second exhaust passage 74, a third jacket portion 51c surrounding an upper side of the second exhaust passage 74, and a fourth jacket portion 51d surrounding a lower side of the second exhaust passage 74.

The opening 74a of the second exhaust passage 74 has a ceiling wall positioned lower than a top portion of a liner 31a of the first or uppermost cylinder 31. This arrangement enables an upper wall 33c of the third jacket portion 51c to be positioned lower than an upper wall 33d defining part of the first cylinder 31, thereby meeting a requirement for making the engine 3 compact. That is, it is not necessary for the cylinder block 33 to have an increased height so as to provide the third jacket portion 51c. It thus becomes possible to provide the third jacket portion 51c, which surrounds the upper part of the second exhaust passage 74, while maintaining the heightwise size of the engine 3 constant. In the figure, reference characters 33f and 33g denote oil passages.

Fig. 12 is a cross-sectional view taken along line XII-XII of Fig. 11, showing th third jacket portion 51c (i. e., the drainage passage 54A provided downstream of the first thermostat 81) communicating with the drainage passag 54 position d downstream of the relief valve 90.

Fig. 13 is a side elevational view of the cylinder block 33 as viewed from the direction of arrow XIII of Fig. 11, showing a portion of the first cooling passage 51A and the drainage passage 54 formed in the side of the cylinder block 33.

The first thermostat 81 indicated by phantom lines is mounted upwardly of the drainage passage 54 and, more particularly, to the upper surface (hereinafter referred to as "thermostat level L1") of the cylinder block 33. The relief valve 90 shown in Fig. 4 is mounted adjacent to an upper part of the drainage passage 54 and, more particularly, to the upper portion (hereinafter referred to as "relief valve level L2") of the side surface of the cylinder block 33, which is proximate to the thermostat level L1. The thermostat level L1 and the relief valve level L2 are vertically spaced from each other by a distance H1. An upper end portion of the cylinder block 33 between the thermostat level L1 and the relief valve level L2 will be hereinafter referred to as "isolated portion A".

Since the relief valve 90 is positioned closely to the first and second thermostats 81, 88 as shown in Fig. 4, the distance H1 between the first and second thermostats 81, 88 and the relief valve 90 is very small. Thus, even under a condition that the first and second thermostats 81, 88 are closed, the relief valve 90 is opened to allow the cooling water to flow through the drainage passage 54, thereby achieving a sufficient cooling effect throughout the entire area of the drainage passage 54 including a wall 33h of the isolated portion A. As a result, the drainage passage 54 is kept at a uniform temperature throughout the length thereof. This further enables an area along the joining surfaces 33a, 34a (see Fig. 10) of the cylinder block 33 and the cylinder head 34 to have a uniform temperature.

Thus, even when the pitch of the bolts 59 (see Fig. 5) for connecting the cylinder block 33 and the cylinder head 34 is increased due to the large-sized cylinder bore necessitated by the up-sizing of the engine, it is possible to attain a cooling function with respect to the joining surfaces 33a, 34a.

Fig. 14 is a cross-sectional view taken along line XIV-XIV of Fig. 13, showing the second water jacket 51 divided into jacket portions (e.g., the first jacket portion 51a and the second jacket portion 51b).

Fig. 15 is a side elevational view of the cylinder head 34 as viewed from the side of the joining surface 34a thereof, showing the combustion chambers 71 arranged in vertical juxtaposition.

The first exhaust passages 73 have openings 73a which open at the joining surface 34a of the cylinder head 34 along the combustion chambers 71 and are surrounded by the bolts 59 as shown in Fig. 5. In the joining surface 34a of the cylinder head 34, there are formed the bolt receiving openings 34b disposed around the openings of the combustion chambers 71 and the open-

ings 73a of the first exhaust passages 73. Th cylinder block 33 (see Fig. 11) and the cylinder head 34 are coupled together by screwing the bolts 59 (see Fig. 5) into the screw openings 33b (see Fig. 11) through the bolt receiving openings 34b.

The cylinder head 34 has a plurality of bolt receiving openings 34c formed at the top and bottom outermost positions (overhung positions) of the joining surface 34a. The cylinder block 34 (see Fig. 11) and the cylinder head 34 are also connected together by the bolts 59 engaged in the bolt receiving openings 34c and screwed into the screw openings 33e.

The first water jacket 52 is composed of a plurality of first jacket portions 52a disposed around the respective combustion chambers 71, a plurality of second jacket portions 52b provided in a row at a right side of the openings 73a of the vertically arranged first exhaust passages 73, a third jacket portion 52c disposed above the first exhaust passage 73, and a plurality of fourth jacket portions 52d disposed below the first exhaust passage 73. In other words, the jacket portions of the first water jacket 52 are so arranged as to surround the combustion chambers 71 and the openings 73a of the first exhaust passages 73. Accordingly, the vicinity of the openings 73a of the first exhaust passages 73 and the vicinity of the opening 74a (see Fig. 11) of the second exhaust passage 74 are equally cooled to thereby suppr ss distortion by exhaust heat of the vicinity of the openings 73a, 74a. Thus, it becomes possible to produce a sufficient seal between the joining surface 33a of the cylinder block 33 and the joining surface 34a of the cylinder head 34.

When the cylinder block 33 and the cylinder head 34 are coupled together, the third jacket portion 52c disposed above the uppermost first exhaust passage 73 communicates with the third jacket portion 51c shown in Fig. 10. This also causes the third jacket portion 52c (i.e., the drainage portion 54B provided downstream of the second thermostat 88) to communicate with the drainage passage 54 provided downstream of the relief valve 90.

With the third jacket portions 51c, 52c (drainage portions 54A, 54B located downstream of the first and second thermostats 81, 88) thus arranged to communicate with the drainage passage 54 provided downstream of the relief valve 90, when the relief valve 90 is opened to allow the cooling water to flow through the drainage passage 54, the cooling water flows into the third jacket portions 51c, 52c, as shown in Figs. 7 and 10. Since the third jacket portions 51c, 52c are cooled by the cooling water flown thereinto, a sufficient cooling effect can be attained throughout the entire area of the joining surfaces 33a, 34a around the drainage passage 75 (see Fig. 8). As a result, it b comes possible to maintain at a uniform temperature the wall defining the drainage passage 54 and the engine portion along the joining surfaces 33a, 34a of the cylinder head 33 and the cylinder head 34. In Fig. 15, reference character 34d designates a breather passag ; and 34 , an oil passage.

It may be readily appreciated by those skilled in the art that in the present invention, the first thermostat 81 may be mounted on the upper surface of the cylinder block 33 while the relief valve 90 may be mounted on the side surface of the cylinder block 33 proximately to the first thermostat 81. For example, the first thermostat 81 and the relief valve 90 may be mounted directly or indirectly onto the cylinder block 33.

Obviously, various minor changes and modifications of the present invention are possible in the light of the above teaching.

Claims

1. An engine cooling system for an outboard motor, comprising:

 a cylinder block (33) having a plurality of cylinders (31) disposed generally horizontally in vertical juxtaposition;
 a cylinder head (34) being capable of coupling with said cylinder block (33);
 a plurality of combustion chambers (71) defined within said cylinder block (33) and said cylinder head (34);
 first exhaust passages (73) formed in said cylinder head (34) for guiding an exhaust gas from said combustion chambers (71);
 a second exhaust passage (74) formed in said cylinder block (33) in such a manner as to communicate with said first exhaust passages (73);
 a first water jacket (52) having jacket portions formed around said combustion chambers (71) of said cylinder head (34);
 a second water jacket (51) having jacket portions formed around said combustion chambers (71) of said cylinder block (33);
 a cooling water passage (50) comprising said first water jacket (52) and said second water jacket (51), said cylinder block and said cylinder head having joining surfaces (33a, 34a) to be connected together by plural bolts (59);
 said second exhaust passage (74) having an opening (74a) which opens at said joining surface (33a) of said cylinder block (33) along said cylinders (31) and is surrounded by said plural bolts (59); and
 said cooling water passage (50) having water jacket portions formed between said bolts (59) in said joining surface (33a) of said cylinder block (33) such that they surround said opening (74a) of said second exhaust passage (74).

2. An engine cooling system for an outboard motor, comprising:

a cylinder block (33) having a plurality of cylinders (31) disposed generally horizontally in v r-tical juxtaposition;
a cylinder head (34) for coupling with said cylinder block (33) to define a plurality of combustion chambers (71);
first exhaust passages (73) formed in said cylinder head (34) for guiding an exhaust gas from said combustion chambers (71);
a second exhaust passage (74) formed in said cylinder block (33) and communicating with said first exhaust passages (73);
a second water jacket (51) having jacket portions for cooling the vicinity of said second exhaust passage (74);
a first water jacket (52) having jacket portions for cooling the vicinity of said first exhaust passages (73); and
a relief valve (90) actuated to open and close said second water jacket (51) and said first water jacket (52) by detecting the pressure of cooling water inside said water jackets (51, 52),
wherein that portion (51c) of said second water jacket (51) which surrounds an upper side of said socond exhaust passage (74), and that portion (52c) of said first water jacket (52) which surrounds an upper side of said first exhaust passage (73) communicate with a drainage passage (54) provided downstream of said relief valve (90).

3. The engine cooling system for an outboard motor, as claimed in claim 2, wherein said first water jacket (52) further serves to cool the vicinity of said combustion chambers of said cylinder head and has at least one thermostat (88) mounted thereto and being capable of opening and closing actions by detecting a temperature of the cooling water within said first water jacket (52), and a drainage passage (54B) is provided downstream of said thermostat (88) such that it communicates with said drainage passage (54) positioned downstream of said relief valve (90).

4. The engine cooling system for an outboard motor, as claimed in claim 2 or 3, wherein said jacket portion (51c) of said second water jacket (51) surrounding the upper side of said second exhaust passage (74) has an upper wall (33c) positioned lower than an upper wall (33d) defining an uppermost one of said cylinders (31).

FIG.1

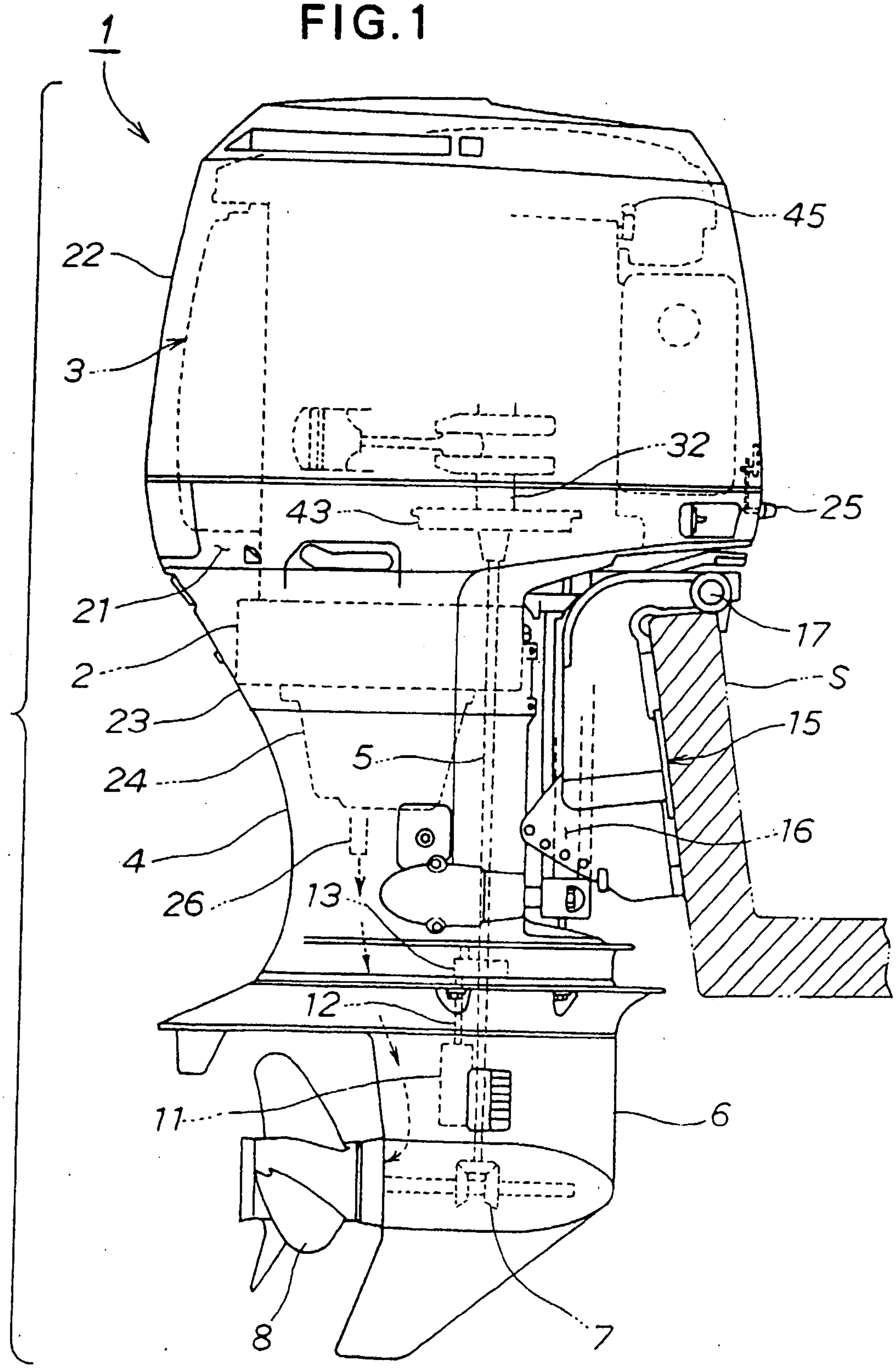


FIG.2

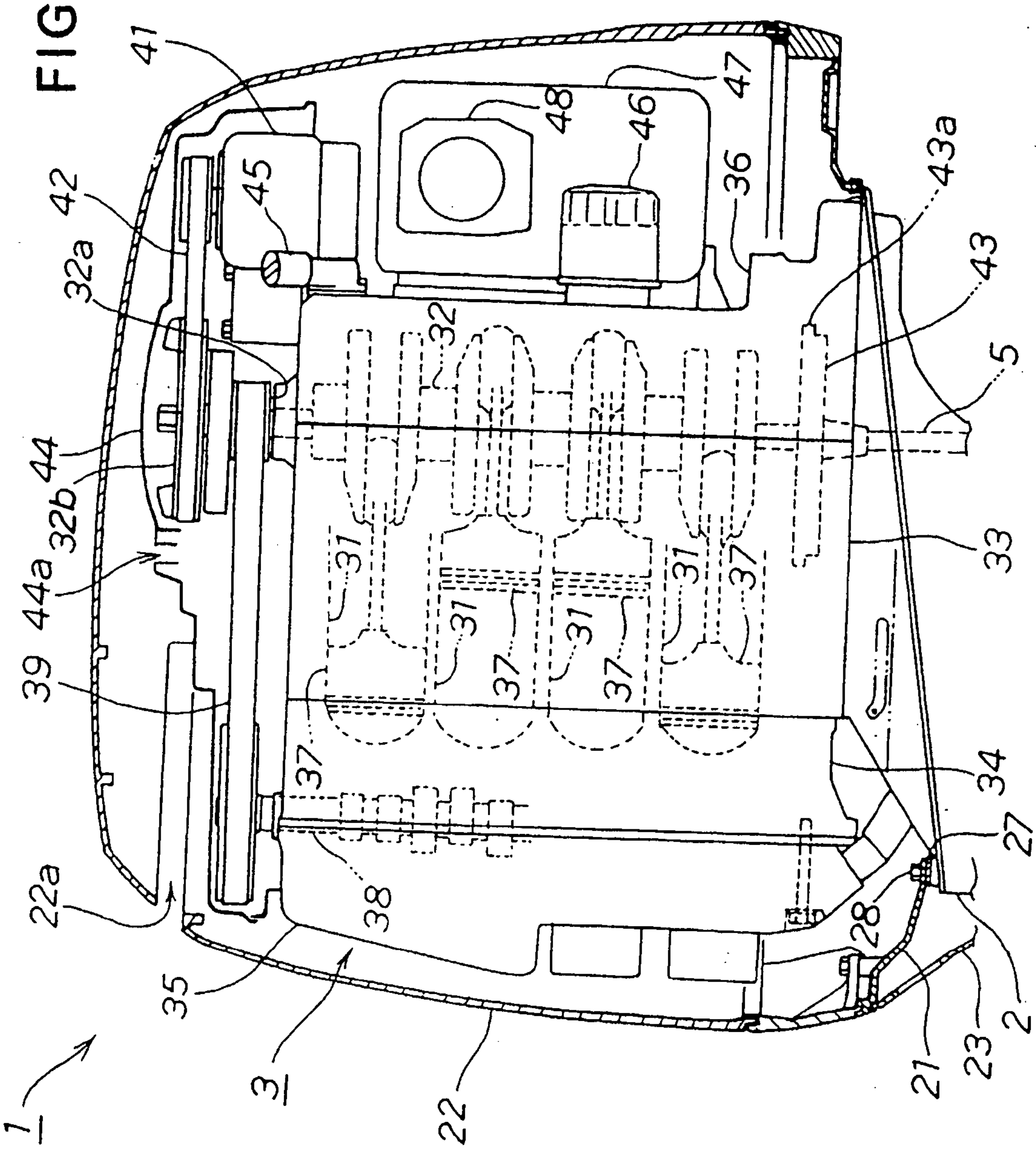

1
3
2
5
21
22
22a
23
27
28
31
32
32a
32b
33
34
35
36
37
38
39
41
42
43
43a
44
44a
45
46
47
48

FIG.3

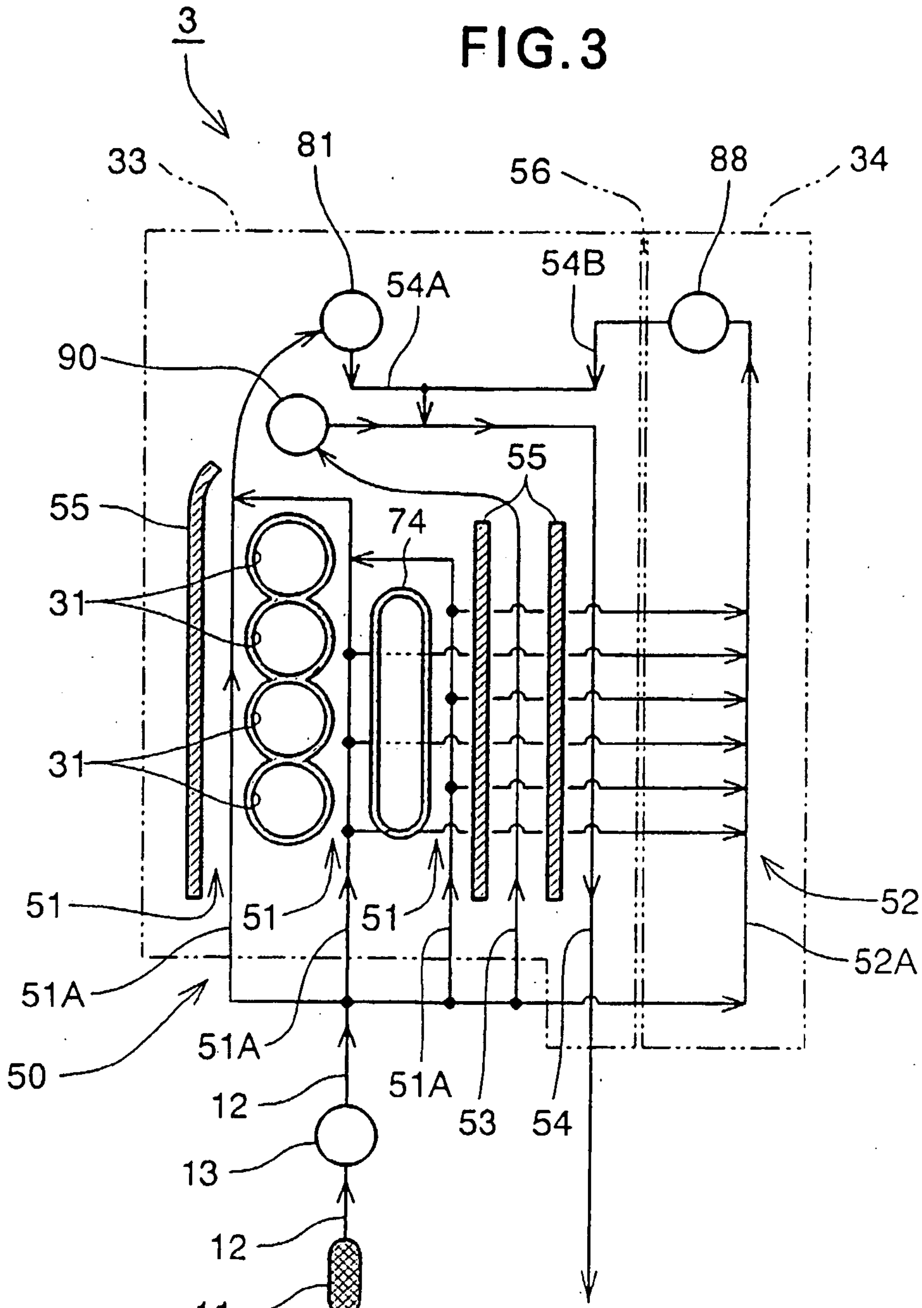

3
33
81
56
88
34
54A
54B
90
55
55
74
31
31
51
51
51
52
51A
52A
51A
50
51A
12
51A
53
54
13
12
11

FIG. 4

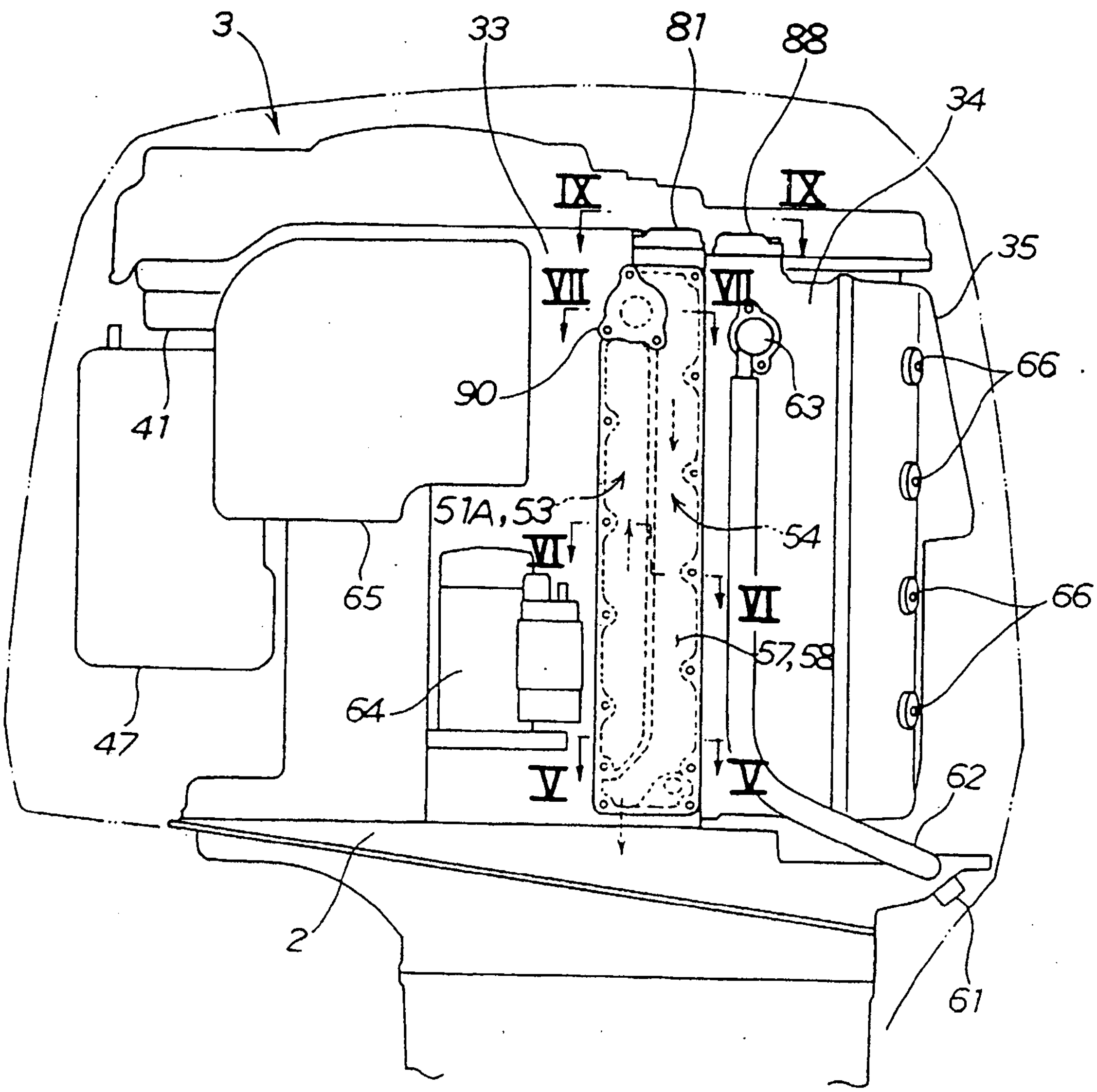

3
33
81
88
34
35
IX
IX
VII
VII
90
63
66
41
51A, 53
54
VI
VI
65
57, 58
66
64
47
V
V
62
2
61

FIG.5

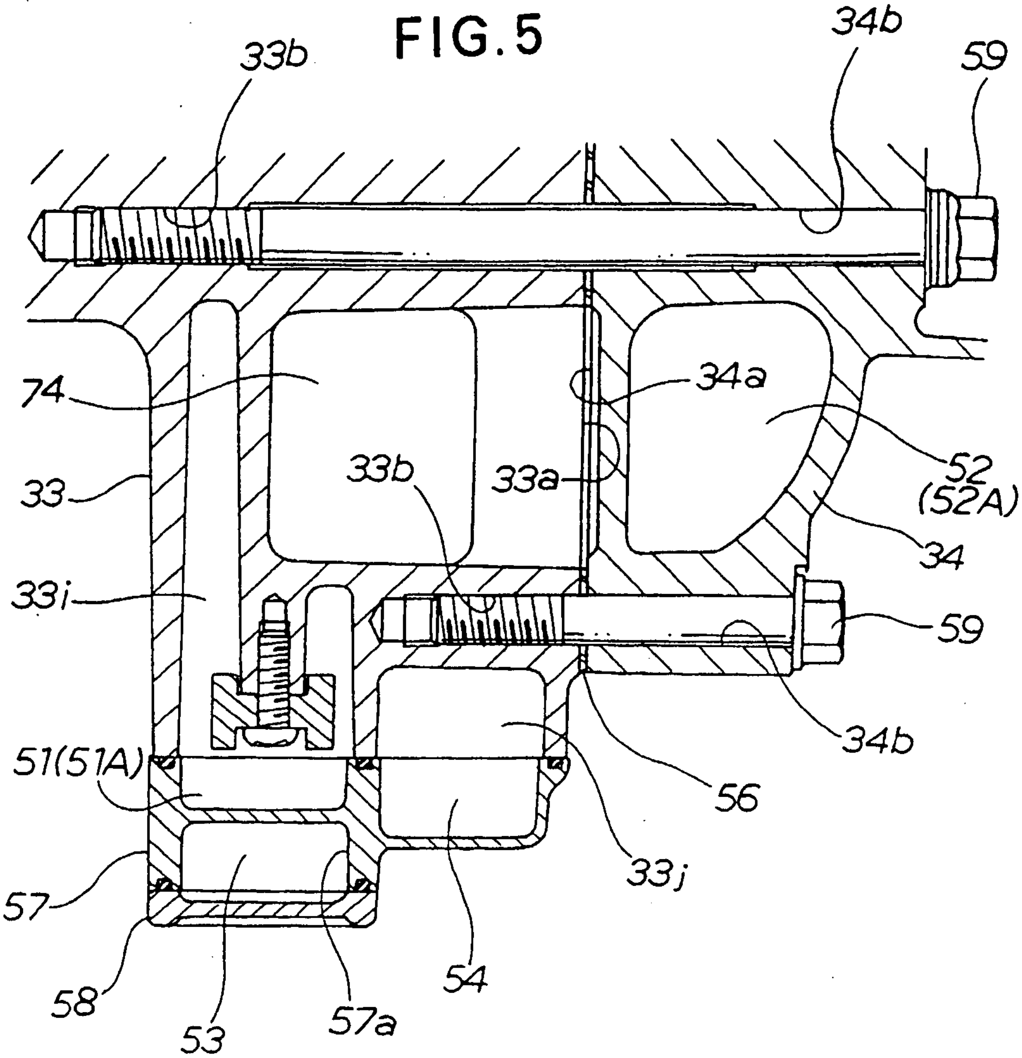

33b
34b
59
74
34a
33b
33a
52
(52A)
33
34
33i
59
34b
51(51A)
56
33j
57
58
53
57a
54

FIG. 6

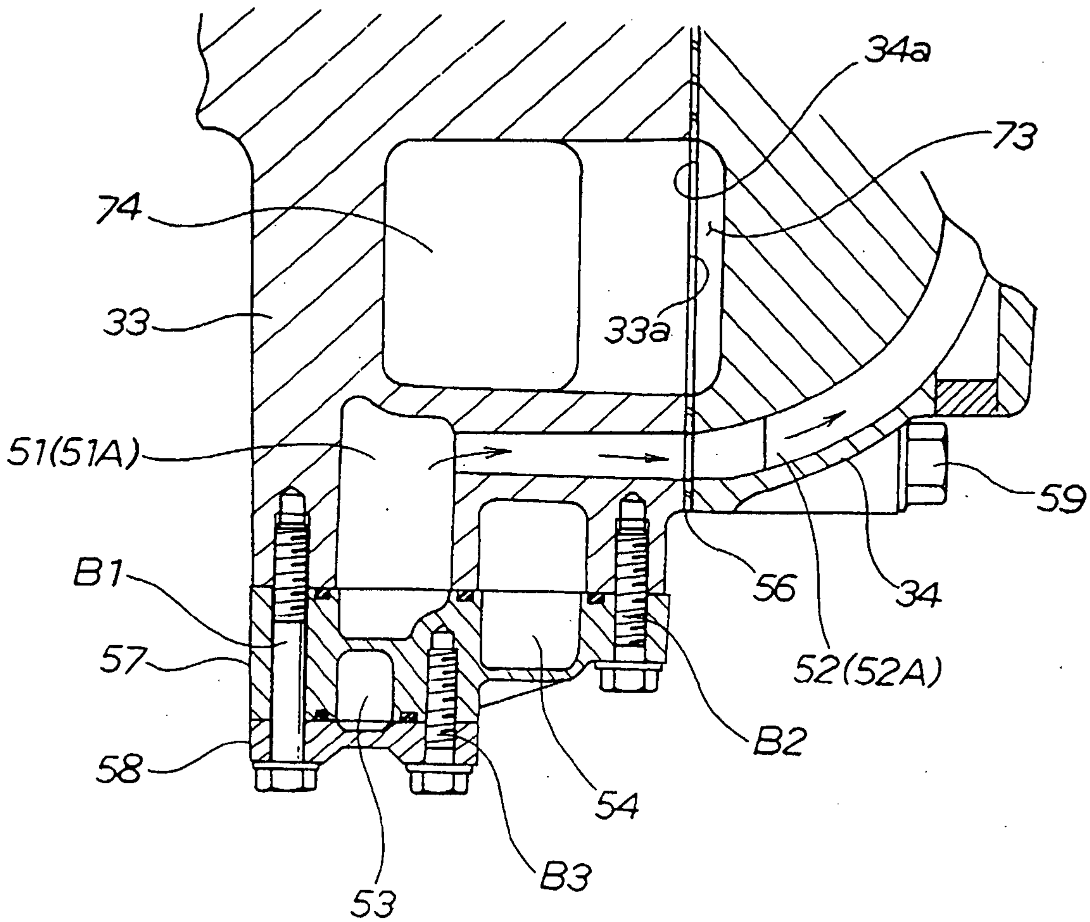
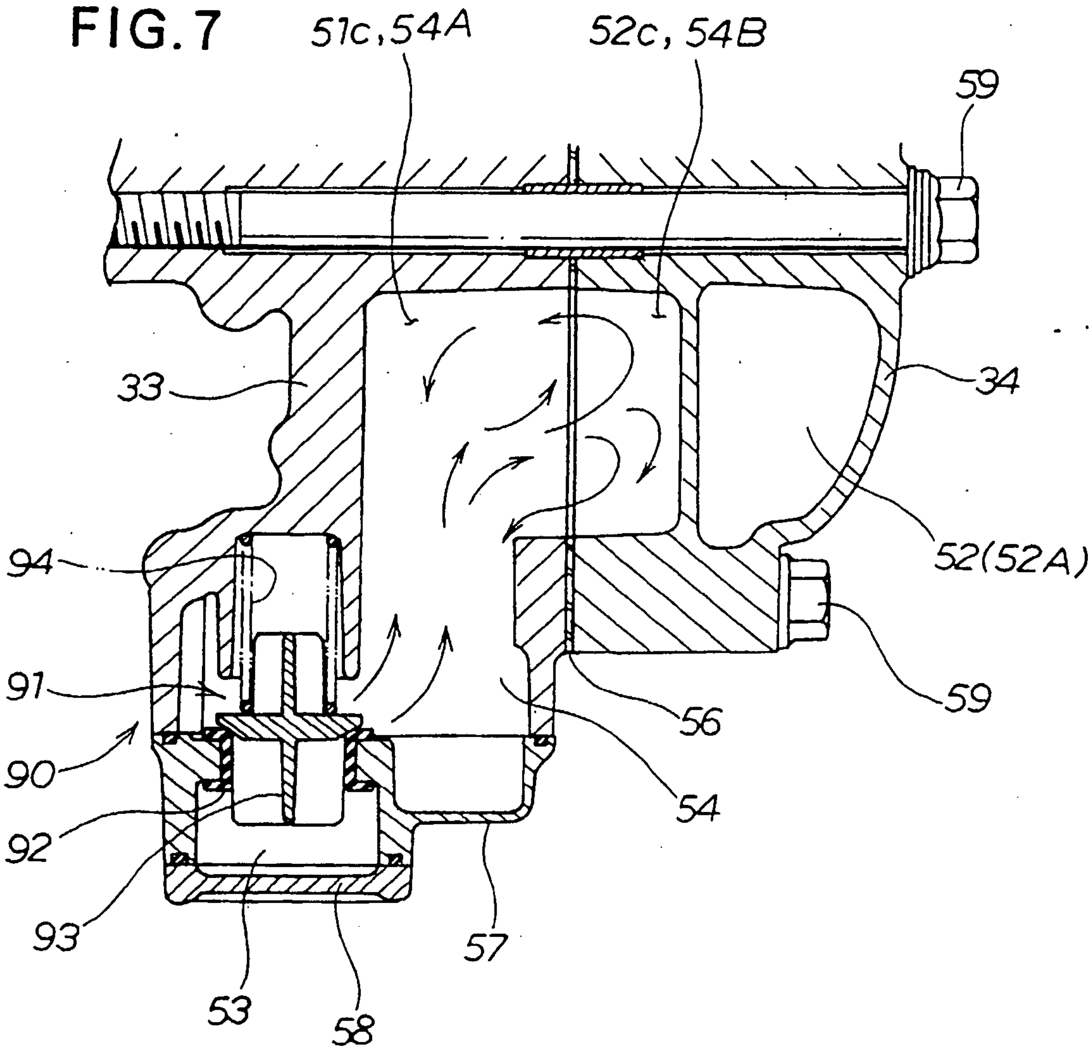


FIG. 7



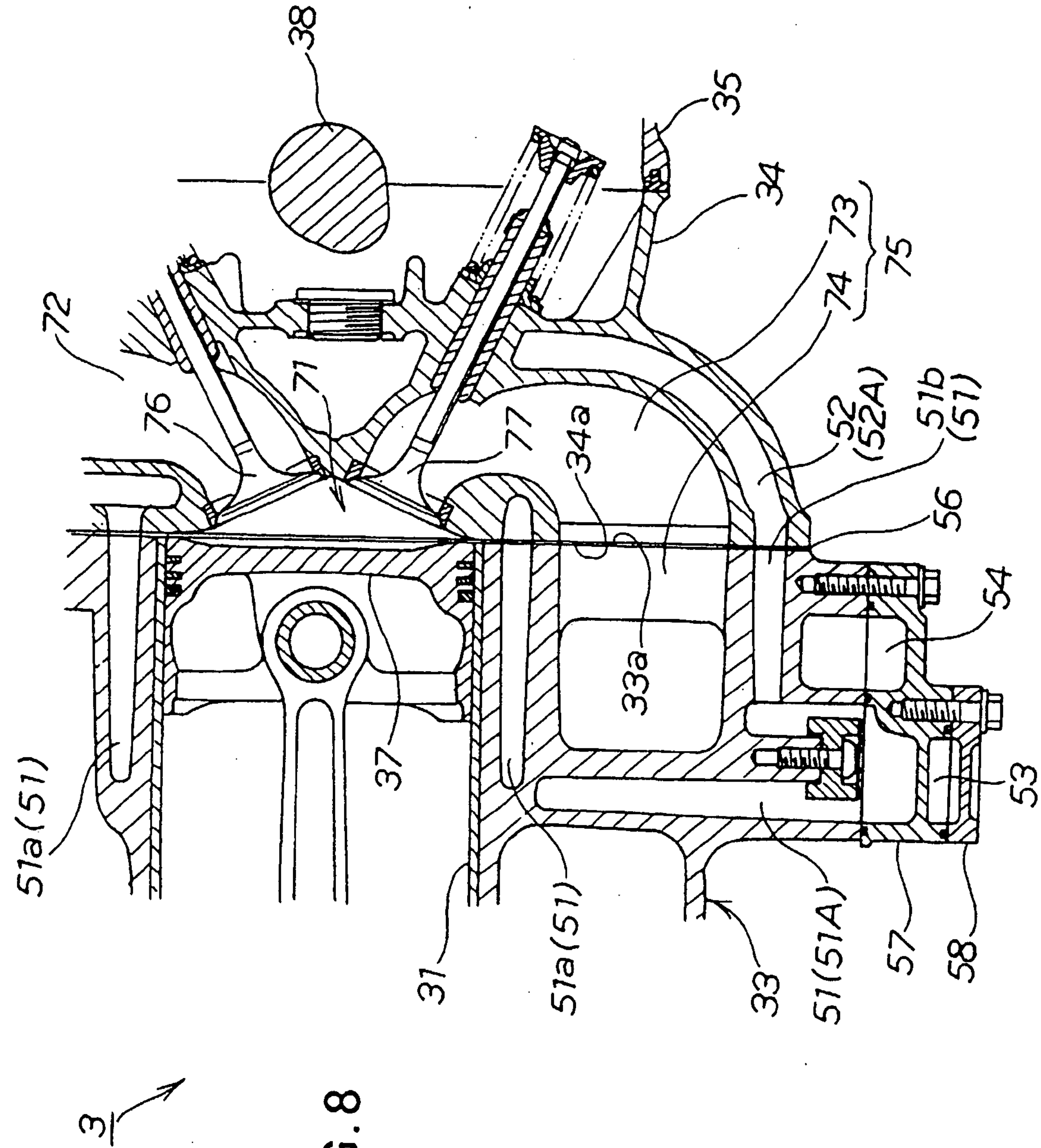

38
35
34
73
75
74
72
71
76
77
34a
52
(52A)
51b
(51)
56
54
33a
37
53
51a(51)
31
51a(51)
33
51(51A)
57
58
3

FIG.8

FIG. 9

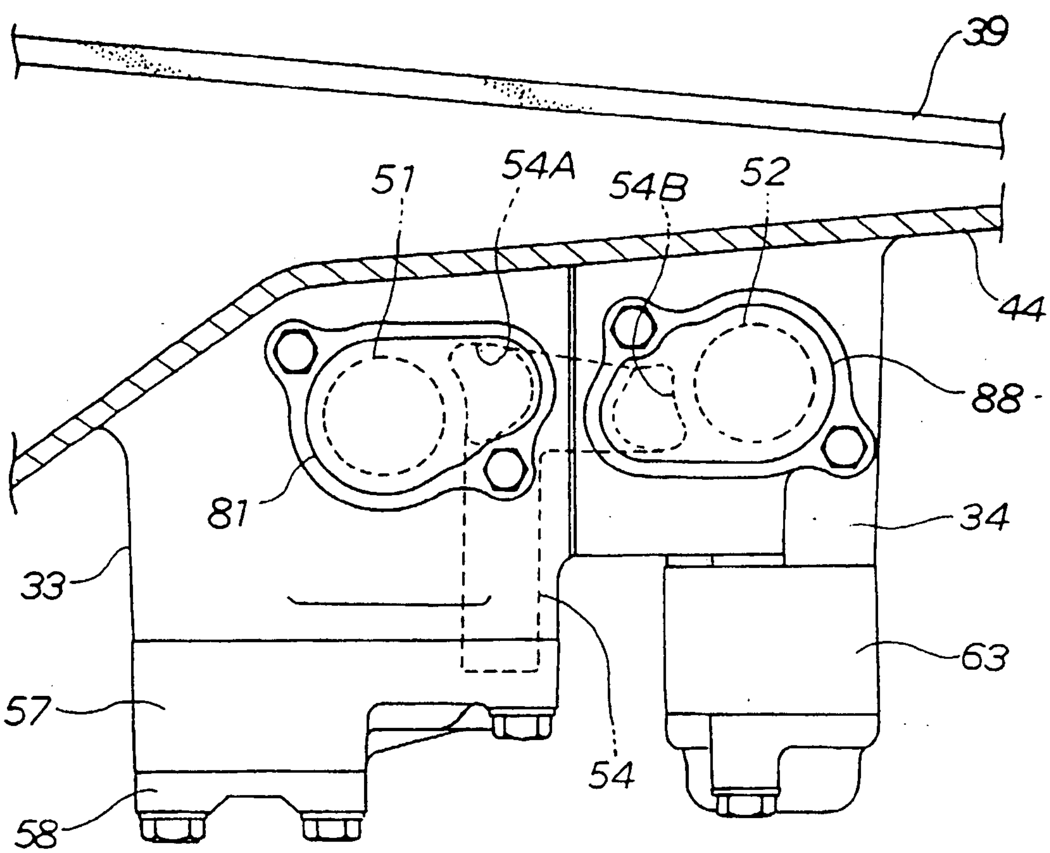


FIG. 10

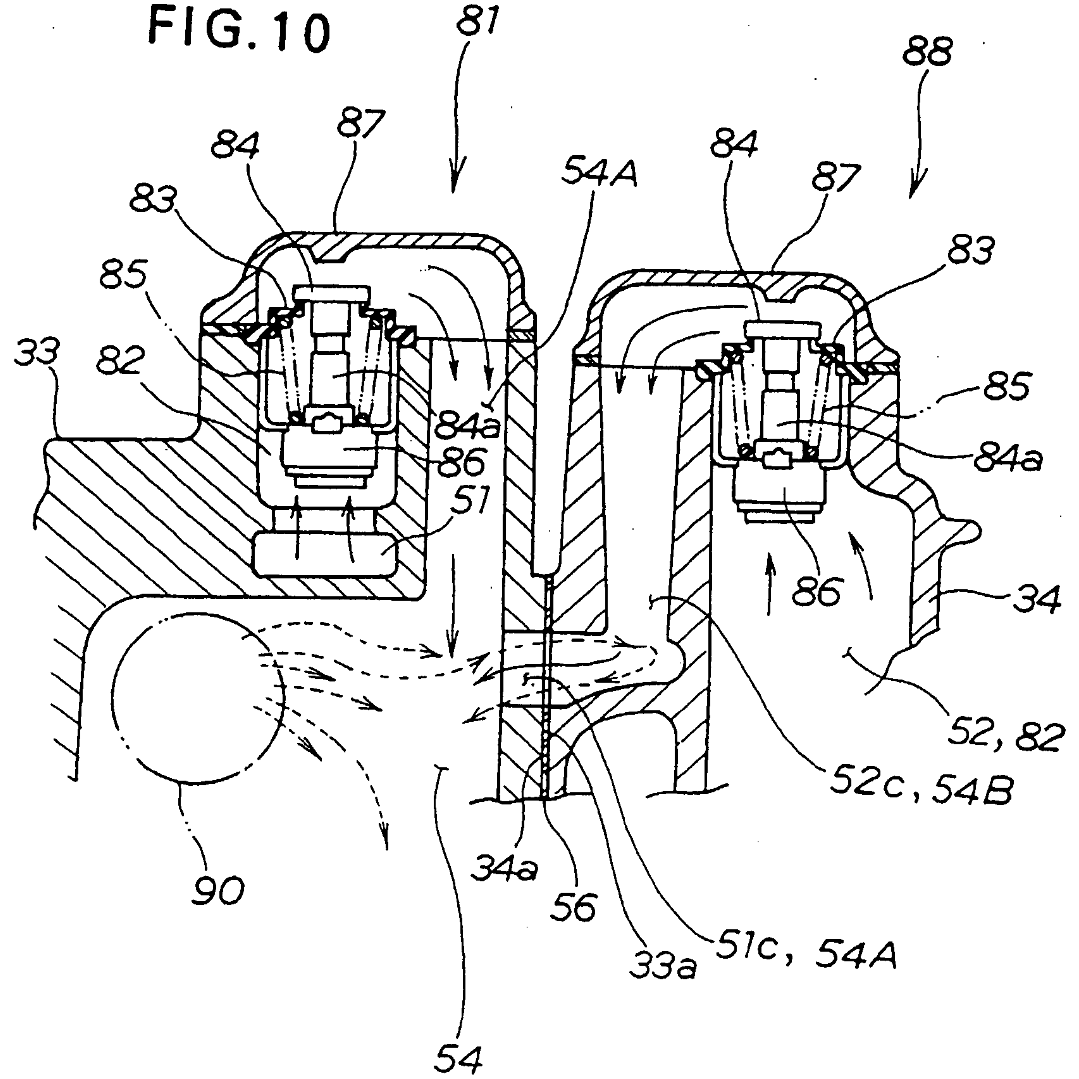

81
88
87
84
54A
84
87
83
83
85
85
33
82
84a
86
84a
51
86
34
52, 82
52c, 54B
90
34a
56
33a
51c, 54A
54

FIG. 11

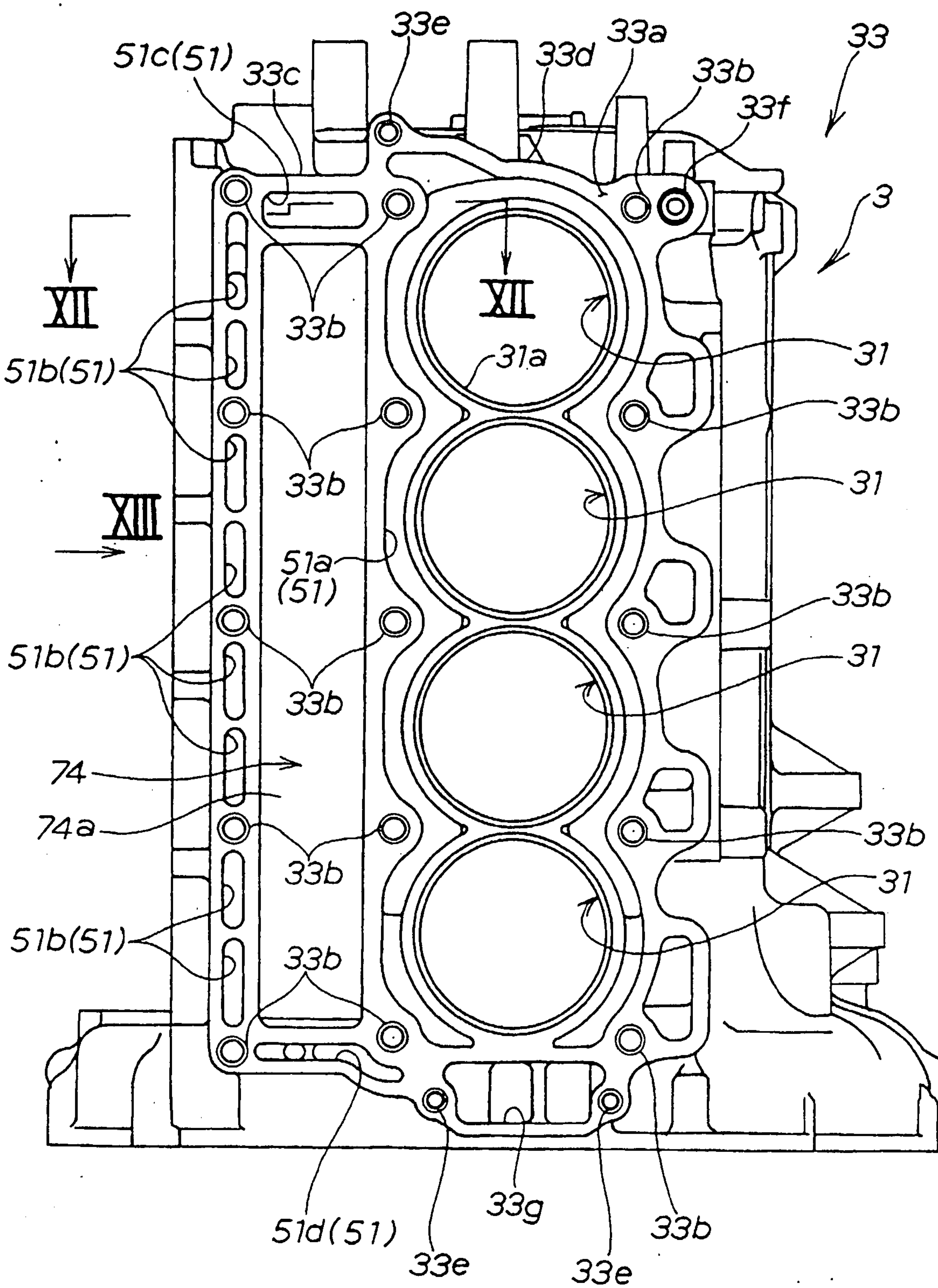

33e
51c(51)
33c
33d
33a
33
33b
33f
3
XII
XII
33b
31
51b(51)
31a
33b
33b
31
XIII
51a
(51)
33b
51b(51)
31
33b
74
74a
33b
33b
51b(51)
31
33b
51d(51)
33g
33b
33e
33e

FIG. 12

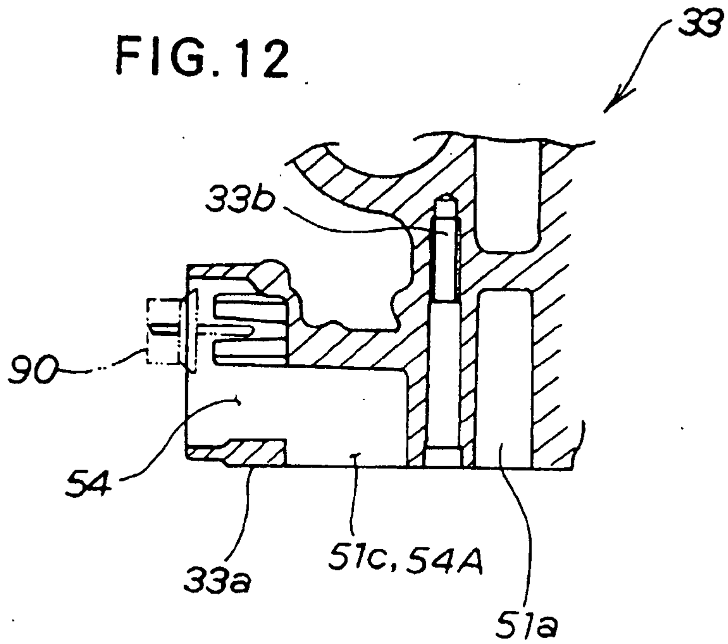


FIG. 14

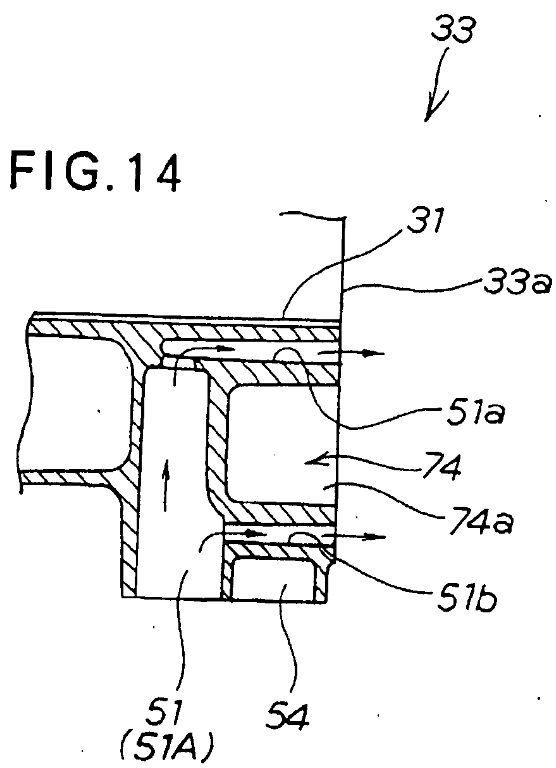


FIG. 13

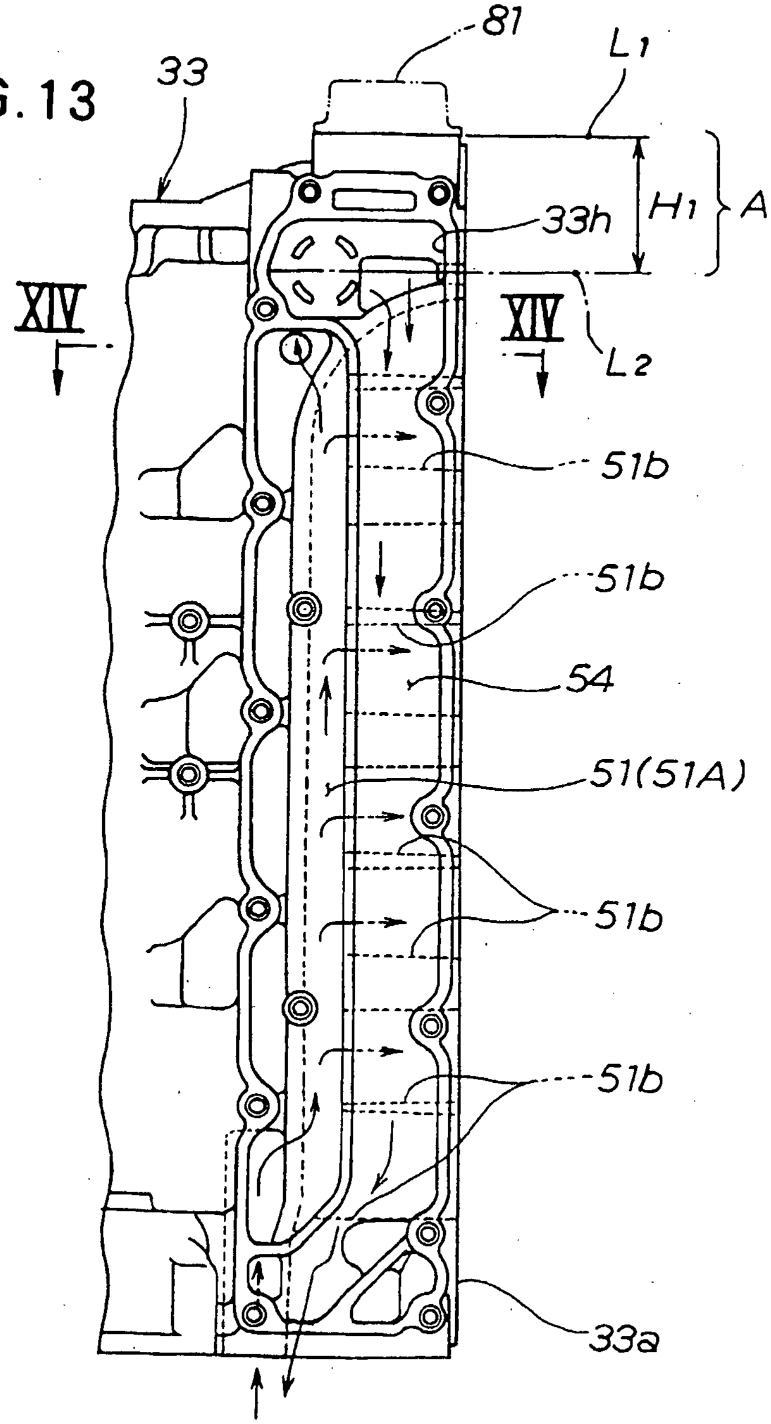
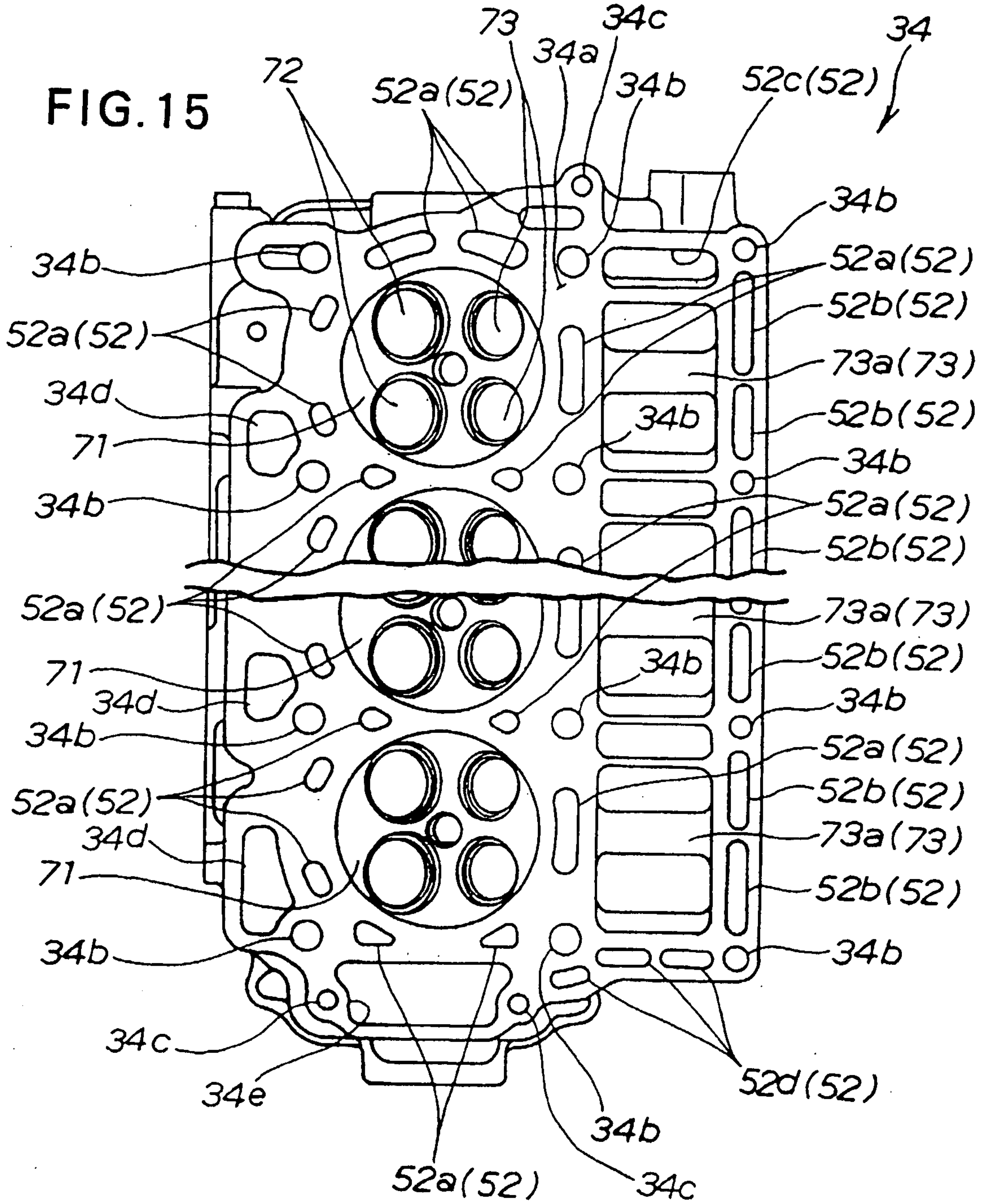


FIG. 15


34
34c
73
34a
72
52a(52)
34b
52c(52)
34b
34b
52a(52)
52b(52)
52a(52)
73a(73)
34d
52b(52)
71
34b
34b
34b
52a(52)
52b(52)
52a(52)
73a(73)
71
52b(52)
34d
34b
34b
34b
52a(52)
52a(52)
52b(52)
34d
73a(73)
71
52b(52)
34b
34b
34c
34e
52d(52)
34b
52a(52)
34c

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 98 10 1848

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
A	PATENT ABSTRACTS OF JAPAN vol. 096, no. 008, 30 August 1996 & JP 08 100658 A (HONDA MOTOR CO LTD), 16 April 1996, * abstract; figure *	1,2	F02B61/04 F01P3/20 F02F1/24 F01P3/12
A	& JP 08 100 658 A * figures *	1,2	
A	PATENT ABSTRACTS OF JAPAN vol. 095, no. 001, 28 February 1995 & JP 06 288297 A (SANSHIN IND CO LTD), 11 October 1994, * abstract; figure *	1	
A	& JP 06 288 297 A * figures *	1	
A	US 5 036 804 A (SHIBATA) * abstract; figures *	1	
A	US 4 621 595 A (SUZUKI) * column 1, line 43 - line 53 * * column 3, line 58 - column 4, line 40; figures *	1	TECHNICAL FIELDS SEARCHED (Int.Cl.6) F02B F01P F02F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	15 April 1998	Kooijman, F

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